

# WATERSHED MANAGEMENT PLAN

## Buckroe Beach and Riley's Way Watersheds



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## EXECUTIVE SUMMARY

The City of Hampton's Department of Public Works commissioned the development of a Watershed Management Plan for the Buckroe Beach and Riley's Way Watershed (Sub-Watersheds 4 and 20) to evaluate existing stormwater infrastructure and identify opportunities to decrease flooding and increase water quality treatment. The combined Buckroe Beach and Riley's Way watersheds consist of 1,661 acres of land draining to the Salt Ponds Inlet and Chesapeake Bay. The watershed primarily consists of medium density residential with smaller areas of commercial development. Figure 1-1 below shows the watershed boundary limits and the study limits for this report.

Many of the floodprone areas within the Buckroe Beach and Riley's Way watershed experience frequent flooding because of effect of tidal surges from nor'easters and hurricanes. Storm events that include tidal surges as well as rainfall can results in extensive areas of flooding within the following areas:

- Area south of Pembroke Avenue
- Area between Pembroke Avenue and Skyland Drive
- Intersection of Pembroke Avenue and Seaboard Avenue
- Area between Chowling Drive and Coach Street

In addition to flooding issues, this study focused on identifying opportunities for improving water quality within the watershed. Stormwater within the City of Hampton is subject to regulations in place by both the Environmental Protection Agency (EPA) and the Virginia Department of Environmental Quality (DEQ). The Commonwealth of Virginia has established Total Maximum Daily Loads (TMDLs) for nitrogen, phosphorus, and sediment in accordance with the TMDLs developed by the EPA for the Chesapeake Bay and a TMDL exists for fecal coliform bacteria in the Back River. Identifying potential locations for new stormwater treatment facilities or retrofitting existing stormwater treatment facilities to enhance bacterial, nitrogen, phosphorus and sediment removal was therefore included as part of this study.

Analysis and identification of potential improvements included coordination with the City's operations and maintenance staff to identify known flooding locations, extensive field work to examine existing conditions within the study area, development of a hydraulic model for the existing conditions using EPA's Storm Water Management Model (SWMM) modeling software, and analysis of proposed improvement alternatives using SWMM. In addition to the hydraulic analysis, pollutant removal rates for the identified options were developed and potential construction cost estimates were prepared for each identified alternative.

A total of ten potential drainage and water quality improvements were identified during the assessment of the subject watershed. One of which directly address flooding issues alone, one of which addresses water quality issues alone, and eight of which address both flooding and water quality. Below is a list of the ten improvements included in this study.

- Merrimack Elementary School – Constructed Wetland
- Jones Magnet Middle School – Bioretention Areas
- Buckroe Shopping Mall – Constructed Wetland
- Buckroe Shopping Mall – Permeable Pavement
- Buckroe Redevelopment – Constructed Wetland
- Amherst Road – Constructed Wetland
- Fields Drive – Constructed Wetland
- Hall Road – Constructed Wetland
- Buckroe Beach Neighborhood – Filterra Systems
- 5<sup>th</sup> Street Flood Improvement

As shown in the table below, the proposed stormwater management improvements were ranked in order of their ability to provide immediate water quality improvements and/or flood reduction improvements with minimal design and property/easement acquisition time.

**Table 5-2: Water Quality Improvement Prioritization**

Priority	Stormwater Feature	Cost per Pound Phosphorous Removed	Land Acquisition Needed?
1	Merrimack Elementary Wetland	\$15,920	No
2	Jones Magnet Middle School Bioretention	\$21,230	No
3	Buckroe Avenue Redevelopment Wetland	\$18,340	Yes
4	Buckroe Shopping Mall Wetland	\$17,260	Yes
5	Amherst Road Wetland	\$15,590	Yes
6	Fields Drive Wetland	\$20,940	Yes
7	Hall Road Wetland	\$32,890	Yes
8	Buckroe Shopping Mall Permeable Pavement	\$20,720	Yes

In addition to the proposed stormwater management facilities above, the 5<sup>th</sup> Street Improvement is recommended to provide a safe thoroughfare across the Salt Ponds and reduce instances of tidal surge flooding for approximately 35 percent of the study area. Detailed descriptions of the above listed improvements are included in Chapter 3 of this report and final conclusions and recommendations are included in Chapter 4.



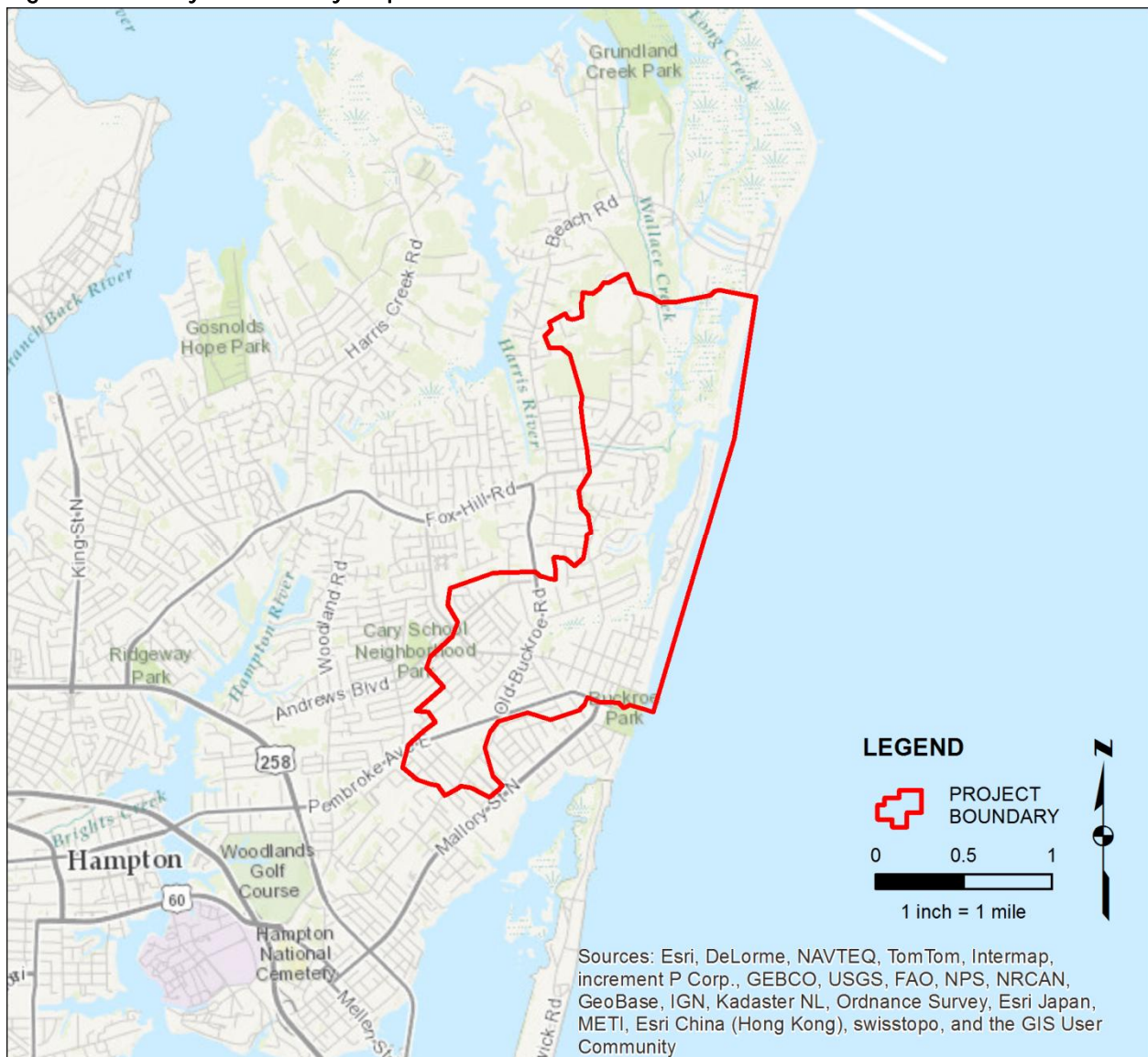
## CHAPTER 1: INTRODUCTION AND BACKGROUND

### A. Purpose

The City's Department of Public Works currently operates all stormwater management improvements and programs through the implementation of a Municipal Separate Storm Sewer System (MS4) program. The MS4 permit allows the City to discharge stormwater runoff to state waters. The City is in the process of systematically addressing watersheds for existing stormwater infrastructure adequacy, condition, capacity, and pollutant removal efficiency to develop watershed specific areas

The study area consists of the Buckroe and Riley's Way sub-watersheds and is centrally located on the City of Hampton's eastern shore along the Chesapeake Bay.

Figure 1-1: Study Area Vicinity Map



The study consisted of comprehensively gathering and reviewing background information, including the review of existing conditions, review of mapping provided by the City of known areas of flooding, and discussions with multiple City departments to identify the stormwater issues and opportunities within the study area. After reviewing the mapped areas of known flooding, field work was completed to inspect the majority of the ditches, drainage structures, stormwater outfalls and pipe network within the study area while paying particular attention to systems with known flooding issues. The collected information was then used to refine the areas for detailed analysis and potential drainage improvement design. Photographs of the study area, taken during the field portion of the analysis, are included as Appendix B.

Improvements contained in this study are aimed at reducing stormwater flooding and providing implementable stormwater management facilities to assist the City in meeting required TMDL water quality goals. The study placed an emphasis on water quality improvements that both improve drainage and help the city meet the requirements of the Chesapeake Bay total maximum daily load (TMDL) established by the U.S. Environmental Protection Agency (EPA). The Chesapeake Bay TMDL is a multistate initiative required under the federal Clean Water Act that sets pollution reduction goals for nitrogen (N), phosphorus (P), and total suspended solids (TSS) in order to restore and protect the Chesapeake Bay.

Preliminary recommendations for drainage enhancements and water quality improvements were identified based on the collected data and field inspection of the watershed. Kimley-Horn developed a watershed model using EPA SWMM software to simulate the stormwater drainage system during normal flow and storm conditions. The model was then calibrated by checking model results against the mapped areas of known flooding throughout the studied watersheds and from citizen input of historical flooding.

## B. Watershed Description

The Buckroe and Riley's Way watersheds encompass approximately 1,661 acres and are moderately developed with a mixture of residential and commercial development. The majority of the development within the watershed is residential and was built between 1940 and 2000. By land cover, the watershed impervious area is less than 25%; however, the developed impervious area is closer to 36% when removing undevelopable land such as the Salt Ponds, tidal wetlands, beach dunes, and open water. See Table 1-1 to the right for land cover data in tabular format.

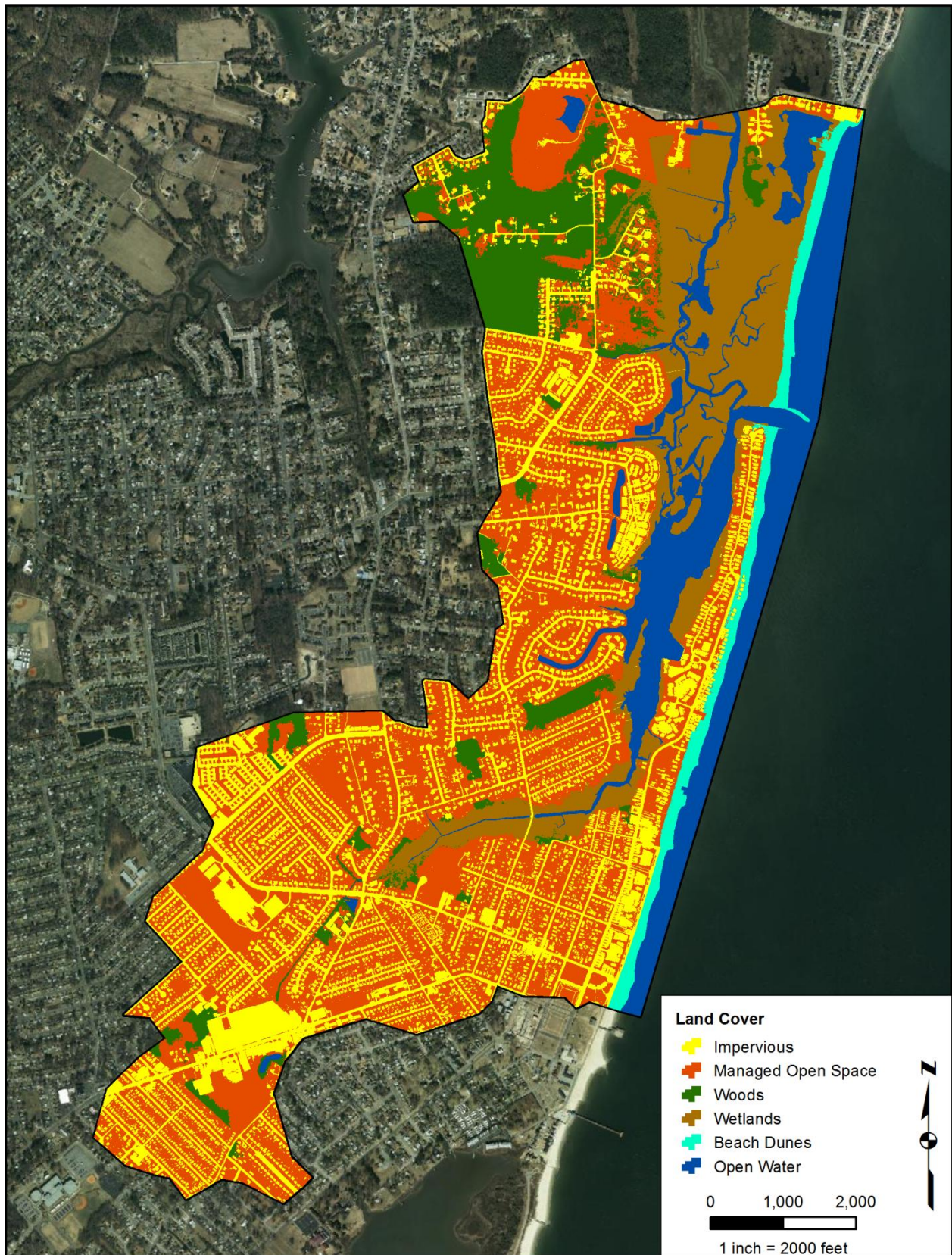
Land Cover Type	Area (acres)	% Total
Impervious	382	23%
Managed Turf	667	40%
Forest	150	9%
Wetland	217	13%
Open Water	203	12%
Beach Dunes	42	3%
Total	1,661	

**Table 1-1: Land Cover Summary**

Figure 1-2 below shows the watershed existing land cover.



Figure 1-2: Land Cover

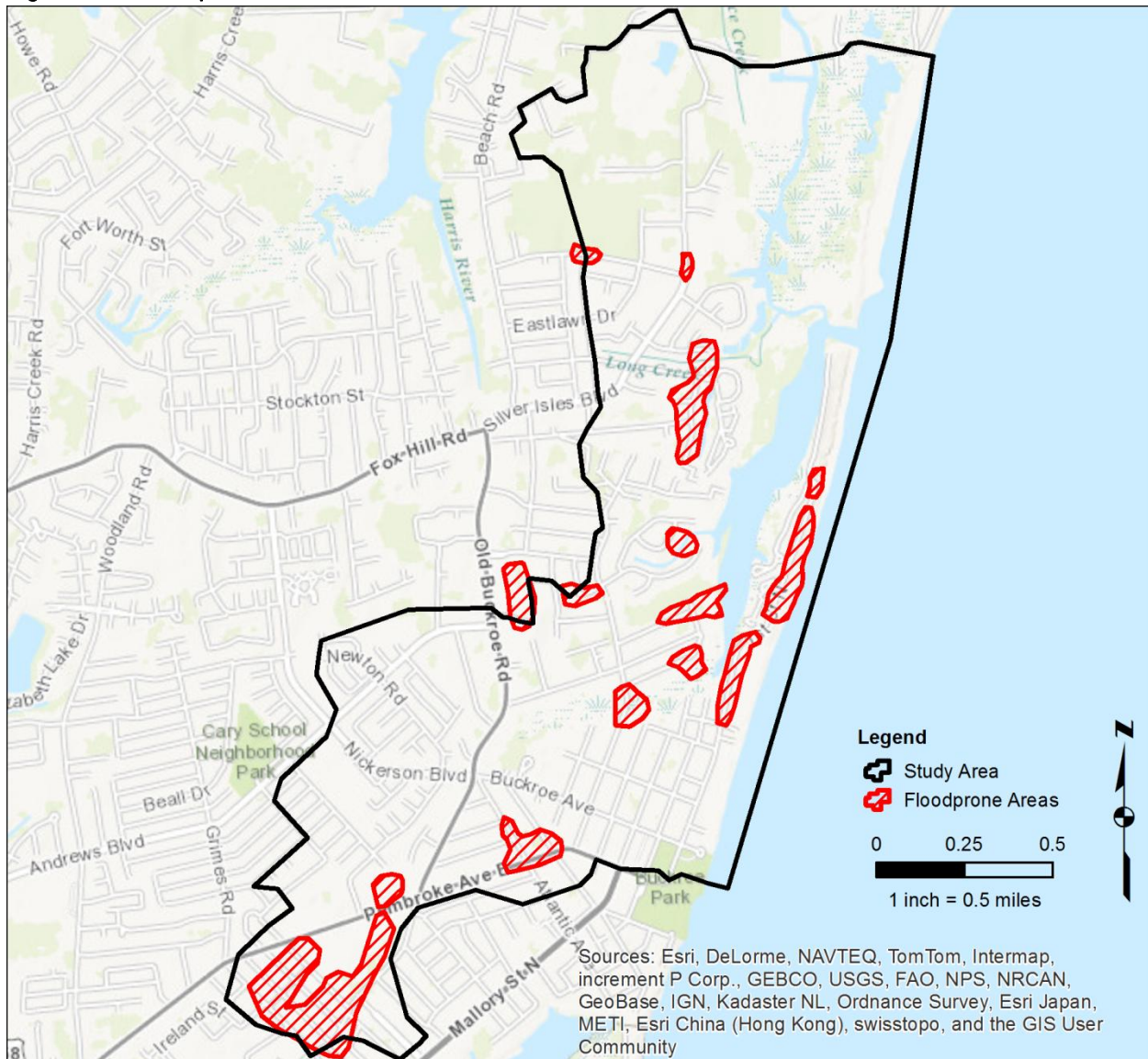




## C. Floodprone Areas

The neighborhoods within the study area contain a mixture of open channel and closed pipe stormwater conveyances. In addition to flooding caused by rainfall, many of the neighborhoods experience flooding due to storm surge from nor'easters and hurricanes in combination with rainfall. This is due to the combination of low elevations, proximity to the Chesapeake Bay, undersized drainage infrastructure, and the higher than normal tides associated with these storm events.

Figure 1-3: Floodprone Areas



Many of the floodprone areas are adjacent to the Salt Ponds or the Chesapeake Bay and are subject to tidal flooding. Measures that protect against tidal flooding include raising houses, increasing roadway elevations, installing surge gates and stormwater pump stations. Additionally, low lying areas near Pembroke Avenue and the Buckroe Common floodprone areas within the watershed are shown in Figure 1-3 above.



## D. Chesapeake Bay TMDL

Stormwater runoff within the City of Hampton is subject to regulations in place by both the U.S. Environmental Protection Agency (EPA) and the Virginia Department of Environmental Quality (DEQ). The Commonwealth of Virginia has established total maximum daily loads (TMDL) for nitrogen, phosphorus and sediment in accordance with the TMDL developed by the EPA for the Chesapeake Bay. TMDLs are limits established by the state or federal government for specific pollutants identified as causing impairments in water bodies. The Chesapeake Bay TMDL is the largest TMDL ever developed by EPA and was established December 29, 2010. The purpose of the Chesapeake Bay TMDL is to have all pollution control measures necessary to restore the Chesapeake Bay and its tidal rivers in place by 2025. A minimum of 5% of these pollution control measures must occur during the first 5-year MS4 permit term.

TMDLs are implemented through the creation of Watershed Implementation Plans (WIP) which specifies the means and methods for reducing the discharge of the pollutants targeted by the TMDL. In January of 2012, a Phase II Watershed Implementation Plan was finalized for the City of Hampton. There are numerous ways in which municipalities can meet the Chesapeake Bay TMDL goals. These include, but are not limited to, the following:

- Improving Existing Administrative and Regulatory Programs, Policies and Practices
- Expanding Public Education and Outreach
- Watershed Restoration and Preservation Activities
- Retrofits to Existing Systems and Structures
- Construction of New Structural BMP Measures

## CHAPTER 2: ASSESSMENT APPROACH

### A. Data Collection

The City of Hampton provided geographic information system (GIS) features that include: stormwater network inventory, 1 foot LiDAR contours, existing land cover, soils, parcels, and land use. Field investigations were carried out by Kimley-Horn to verify the provided stormwater system data and initial sub-catchment delineations, determine which features would require survey, and assess potential stormwater management facilities. Before field investigations began, an existing-conditions layout of the Buckroe and Riley's Way sub-watersheds was developed in ArcGIS. This layout integrated the stormwater inventory, satellite imagery procured through the ESRI ArcGIS Map Service, and a digital elevation model (DEM) created from the received LiDAR contours. Preliminary catchment delineations also were prepared based on the available elevation data. Field investigation focused on major ditches, pipes, inlet structures near known areas of flooding, and outfalls.

After the field investigation, areas were identified for further study using a hydrodynamic model. The detailed hydraulic study area begins at the 5<sup>th</sup> street intersection of the salt ponds. To verify existing stormwater network structures, Michael Surveying & Mapping, P.C. was contracted to survey approximately 200 structures and 28 transects. This survey was incorporated into the hydrodynamic model while pipes with a diameter less than 24 inches were excluded.

### B. Model Development

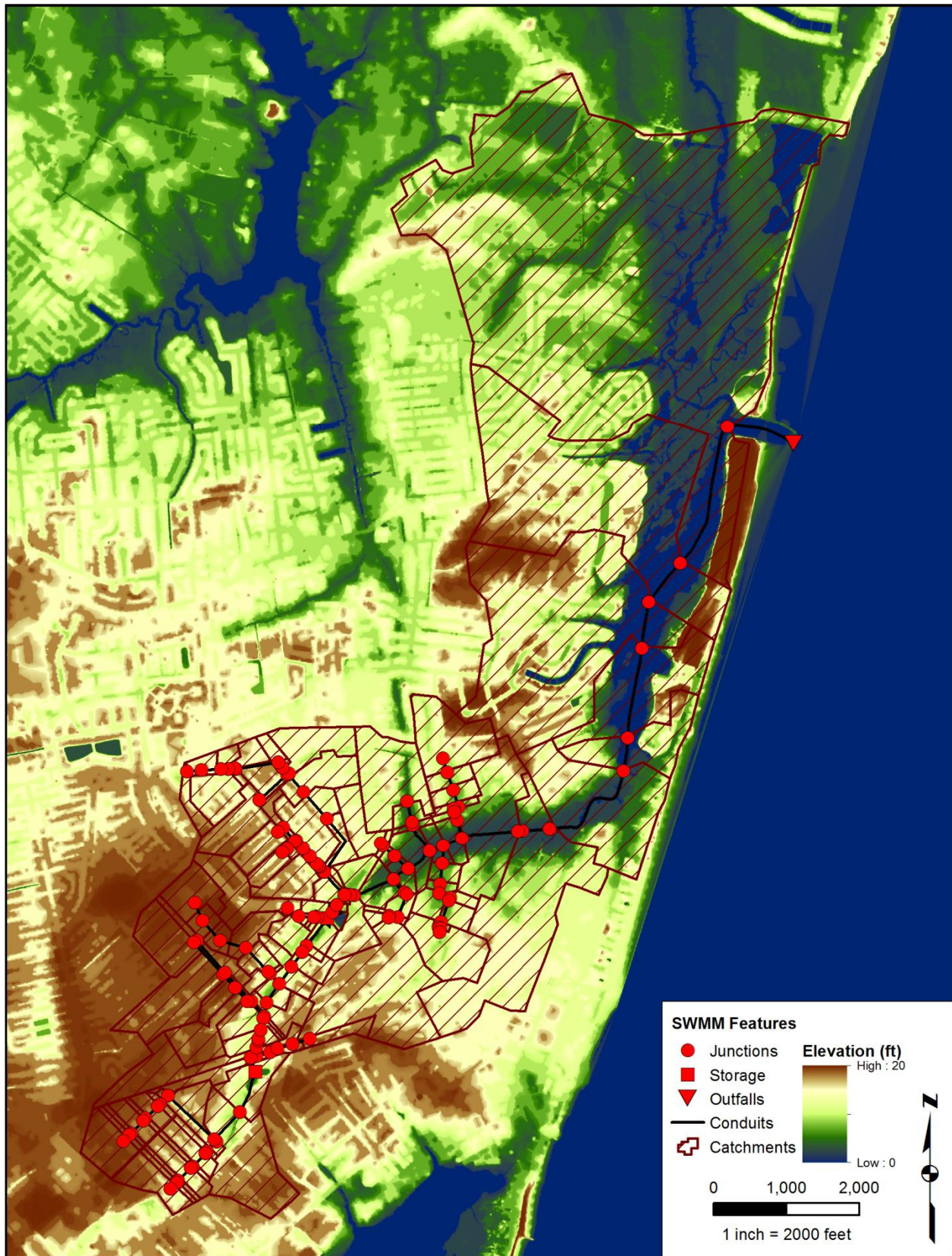
#### Study Area

Because of the dynamic nature of the watershed drainage system coupled with the discharge of watershed runoff to the tidally-controlled Salt Ponds, EPA SWMM modeling software was used to create a hydrodynamic model of the watershed so that flood mitigation options could be simulated. Based on historical flooding data, areas of frequent flooding recorded by the City, and field investigation, it was determined that the neighborhoods in the southern portion of the watershed are the areas where flooding is of most concern. These neighborhoods were therefore selected for the detailed modeling assessment.

#### Stormwater Network

A geodatabase of model features was created in GIS and used to create a hydrologic and hydraulic modeling network within SWMM. The network consisted of nodes to represent stormwater inlets, ditch ends, open-end pipes, storage areas, and outfalls and links to represent stormwater pipes, ditches, natural channels, and weirs. The general layout of the network included the stormwater drainage systems within watershed networks and the main collector links from these systems, which discharge to the Chesapeake Bay. Figure 2-1 below shows a layout of the link/node schematic. A detailed map of the SWMM model schematic is included in Appendix A.

Figure 2-1: SWMM Model Schematic





## Catchment Data

Catchment surface routing within the SWMM model was based on SWMM runoff and transport calculation routines with infiltration defined through the use of the curve number method. Catchment area, percent impervious, width, and ground slope values were generated using ArcGIS. The imperviousness of each catchment was determined using land cover received from the City and discussed in Section 1-B. Curve numbers were assigned to land covers based on TR-55 values for hydrologic soil group (HSG) D soils. Internal catchment routing between impervious and pervious areas was not performed, and therefore 100% of the runoff from each catchment was routed to the outlet. Catchment width was set equal to catchment area divided by the average length of slowest flow. Overland flow moving from residential lots to the street gutter is slower than flow moving from the gutter to inlets; therefore, Manning's n values for pervious surfaces was 0.15 and impervious surfaces was 0.02. An average ground slope of 1% was set for each catchment based on GIS contour data and field survey. Manning's n-values for transects and catchment routing was based upon field observation. Storage curves for storage nodes were generated using GIS contour data and field survey.

## Modeling Scenarios

Simulation scenarios for the modeling analysis included synthetic storm scenarios. Tide stage data for Sewells Point was downloaded from NOAA and calibrated with tide stage data observed in the Hampton Salt Ponds during an October 2013 field investigation. The Salt Ponds tide stage data was similar in magnitude and only slightly delayed in time, indicating the attenuation of tidal waves from Sewells Point to the Salt Ponds is minimal during average daily tides. Flooding conditions caused by heavy rainfall within the study area were evaluated using four synthetic storm event simulations. These included SCS Type II 2-year and 10-year, 24-hour rainfall events, each timed with both the high daily tide and 5-yr surge of 4.74 feet.

## C. Model Results

After running the SWMM scenarios, results were exported into GIS and processed into flooding rasters. To create the flooding raster, a water surface elevation TIN (triangulated irregular network) is created in GIS by interpolating the maximum hydraulic grade line (HGL) results from the link/node schematic. This water surface elevation TIN is then intersected with the existing terrain and areas with values greater than zero are digitized into a flooding depth raster. This method is an approximation tool that helps to visualize flooding results. This hydraulic model focused on stormwater pipes equal to or larger than 24 inches in diameter in order to assess the primary drainage network features. Smaller diameter pipes in the uppermost portions of the sub-catchments were not studied in detail within the model.

Figures 2-2 and 2-3 below illustrate modeled flooding extents of the 2- and 10-yr rainfall events modeled in combination with both the mean high tide and 5-yr surge for the existing site conditions. The modeled results confirm the areas identified by the City as areas most prone to frequent flooding. Stormwater infrastructure downstream of 5<sup>th</sup> street was not modeled; therefore, flooding results in these areas reflect surge elevations.

Figure 2-2: Existing 2-yr Rain Flooding Depths

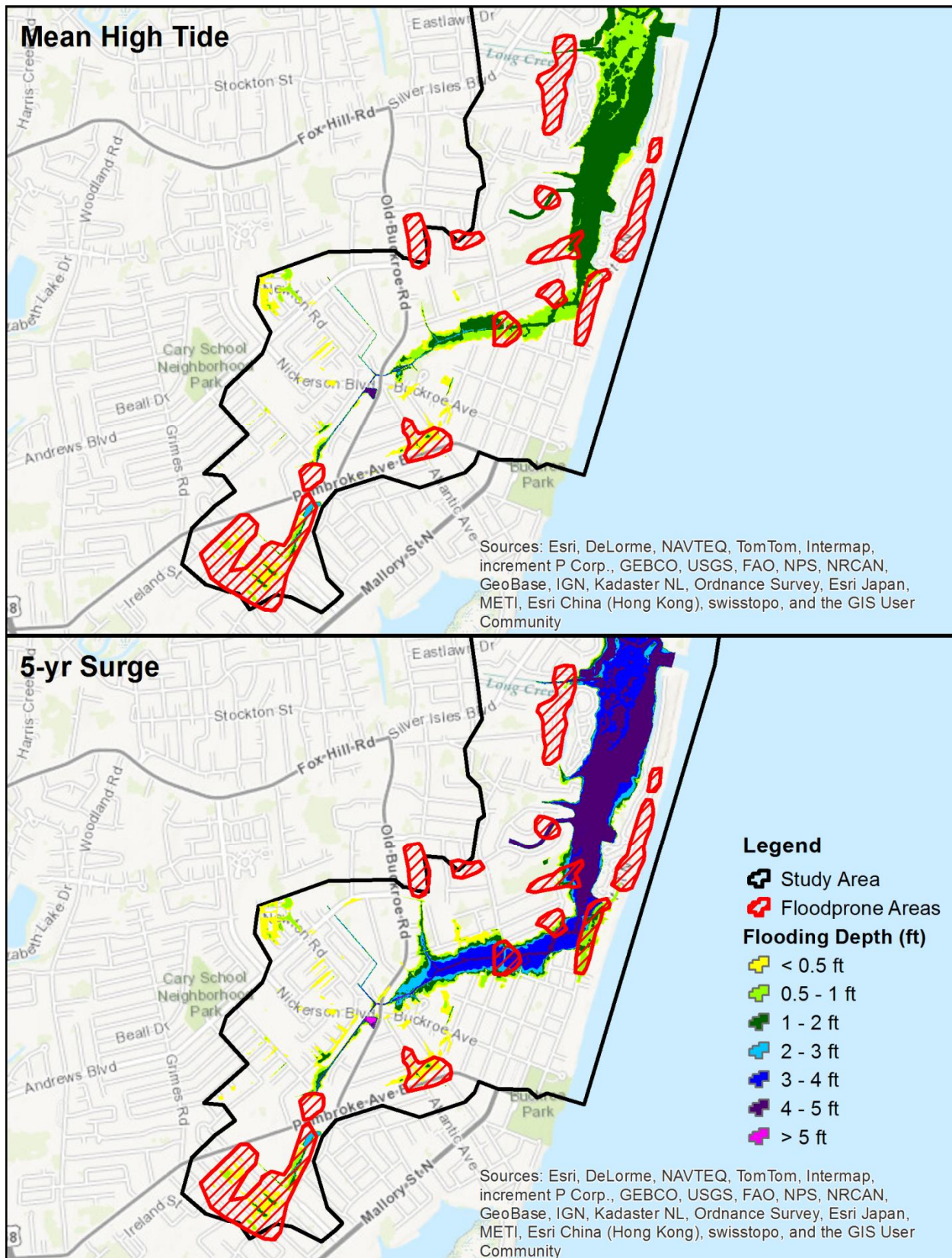
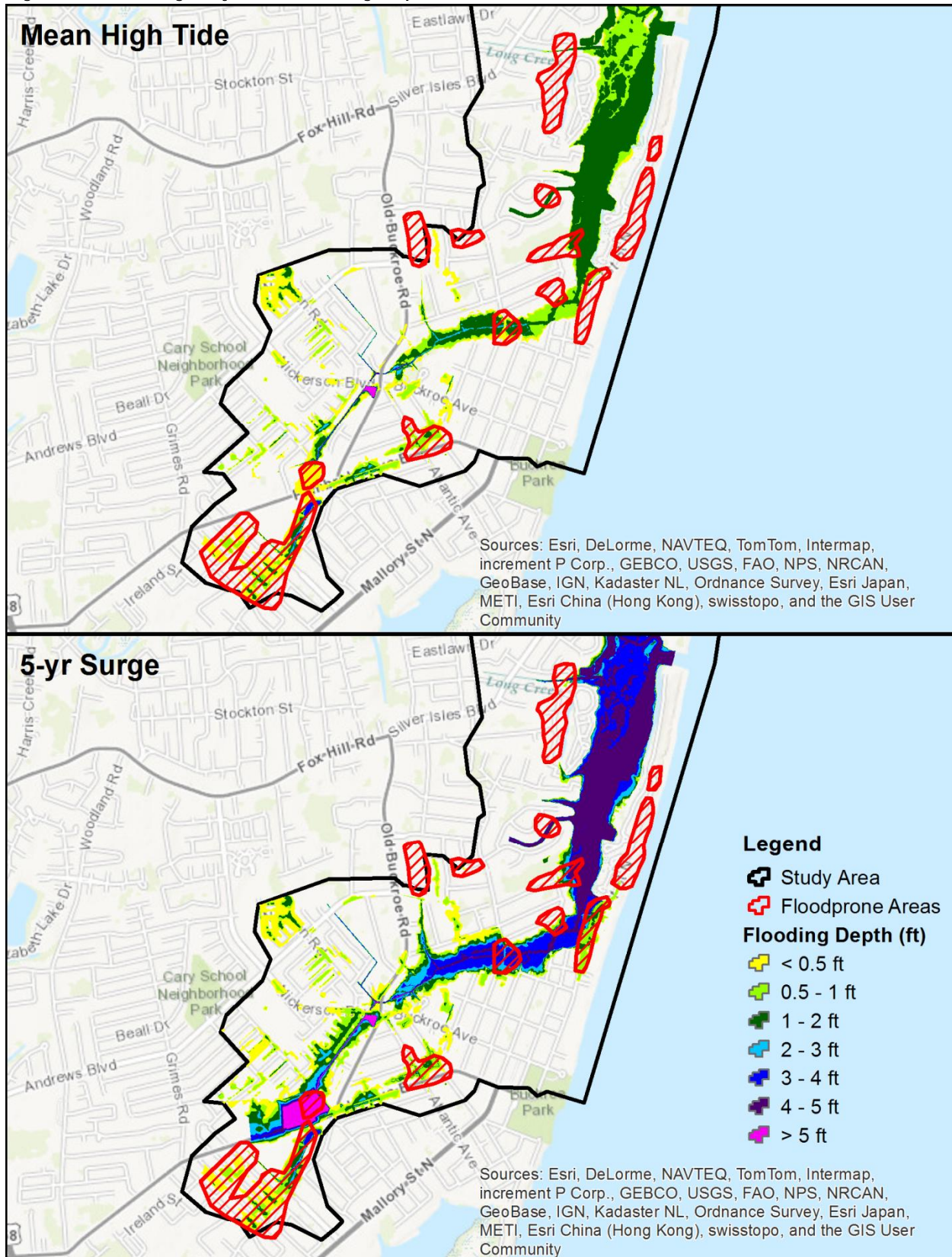




Figure 2-3: Existing 10-yr Rain Flooding Depths





## D. Water Quality Assessment

Existing water quality loading was determined with the use of soils data, land use data, and land cover data input into the Virginia Stormwater Management Program Runoff Reduction Method (VSMP RRM) spreadsheet. Soils data was obtained and hydrologic soil groups were delineated utilizing data from the United States Department of Agriculture (USDA). Land use data was obtained by the City Land cover data for the City of Hampton, which was prepared by Kimley-Horn using ERDAS Imagine software. Land cover types analyzed included impervious area, managed turf, forest, wetland, and open water. The VSMP RRM spreadsheet assigns runoff coefficients to each hydrologic soil group and land cover type. Using this data, as well as the drainage area size and annual rainfall, the yearly pollutant loads were determined for various potential improvements.

## CHAPTER 3: STORMWATER MANEGAMENT FACILITIES

There is an assortment of stormwater management facilities that are capable of providing passive nutrient reduction to meet the Chesapeake Bay TMDL nutrient reduction goals. Not all facilities are appropriate for any situation. Site constraints such as contributing drainage area, land use, open space availability and orientation, and public safety considerations should be taken into account which facility to implement. Below is a list of DEQ approved facilities, a brief summary of each, and the approved water quality performance rates as detailed in the Virginia Stormwater BMP Clearinghouse.

### Bioretention

Bioretention areas, also known as rain gardens, are an efficient stormwater management facility for nutrient removal. Runoff is directed towards shallow basins which temporarily pond stormwater between 6 to 12 inches before rapidly filtering through an engineered soil media. Since Bioretention areas are often landscaped with attractive plants, they are generally accepted by the community and can act as a desirable landscaping amenity.



Bioretention areas are limited to smaller catchment areas with the maximum desired contributing drainage approximately 2-2.5 acres and are well suited to smaller or fragmented catchment areas. They are best suited to highly impervious areas and can be negatively impacted by unstable or eroding soils. Urban applications are possible by fitting Bioretention areas into concrete containers or planters behind curb and gutters within the road right-of-way.

Table 3-1: Bioretention Area Water Quality Performance Table

Stormwater Function	Level 1	Level 2
Annual Runoff Volume Reduction (RR)	40%	80%
Phosphorus Load Reduction	25%	50%
Total Phosphorus Reduction	55%	90%
Nitrogen Load Reduction	40%	60%
Total Nitrogen Reduction	64%	90%

## Constructed Wetland

Constructed wetlands are engineered stormwater management facilities that treat runoff by mimicking the natural processes of wetlands to adsorb, filter, and detain stormwater. Constructed wetlands feature an array of topology to promote a variety of biodiversity and pollutant removal processes. To consistently maintain levels of water within the wetland, contributing drainage areas are relatively large and the connection to groundwater is a necessary design parameter.



**Table 3-2: Constructed Wetlands Water Quality Performance Table**

Stormwater Function	Level 1	Level 2
Annual Runoff Volume Reduction (RR)	0%	0%
Phosphorus Load Reduction	50%	75%
Total Phosphorus Reduction	50%	75%
Nitrogen Load Reduction	25%	55%
Total Nitrogen Reduction	25%	55%

## Dry Swale

Dry swales are similar to bioretention areas and use engineered soil media to filter stormwater runoff, but use turf instead of mulch or ornamental plants. The pollutant removal rate of dry swales is lower than bioretention level 2 design. Dry swales are typically well-suited for highway and low density residential areas. Because dry swales are designed to drain within 6 hours of a storm, they do not tend to foster mosquitoes in well-maintained swales. Dry swales require more frequent maintenance than bioretention areas and are best suited to areas with weekly lawn and landscaping maintenance.

**Table 3-3: Dry Swale Water Quality Performance Table**

Stormwater Function	Level 1	Level 2
Annual Runoff Volume Reduction (RR)	40%	60%
Phosphorus Load Reduction	20%	40%
Total Phosphorus Reduction	52%	76%
Nitrogen Load Reduction	25%	35%
Total Nitrogen Reduction	55%	74%



## Grass Channel

Grass channels act as a conveyance substitute for traditional curb and gutter. They can provide a modest volume of nutrient reduction through runoff filtering. Grass Channels rely on infiltration to reduce runoff volumes; therefore, they are heavily influenced by soil permeability rates. Poorly drained soils can be amended with compost to increase nutrient removal rates. Grass swales are linear in nature and are well suited to treat highway, low density residential development, or sports fields.



Grass swales are an economical choice for nutrient reduction and can be used in sequence with other stormwater management facilities to maximize nutrient reduction. The urbanized nature of the study area limits the practical application to retrofit areas with currently underutilized open space.

Table 3-4: Grass Channel Water Quality Performance Table

Stormwater Function	No CA*	With CA*
Annual Runoff Volume Reduction (RR)	10%	30%
Phosphorus Load Reduction	15%	15%
Total Phosphorus Reduction	24%	41%
Nitrogen Load Reduction	20%	20%
Total Nitrogen Reduction	28%	44%

\*CA: Compost Amended Soils

## Infiltration

Stormwater sand filters are effective at treating highly impervious sites by filtering runoff through engineered filter media. Stormwater filters require a small surface area and provide a moderate nutrient removal rate; however, since they provide no runoff reduction, they are best suited to follow another stormwater management facility that reduces runoff volume. Stormwater filters generally quite versatile because they have few site restrictions.



Table 3-5: Infiltration Water Quality Performance Table

Stormwater Function	Level 1	Level 2
Annual Runoff Volume Reduction (RR)	0%	0%
Phosphorus Load Reduction	60%	65%
Total Phosphorus Reduction	60%	65%
Nitrogen Load Reduction	30%	45%
Total Nitrogen Reduction	30%	45%

### Permeable Pavement and Underground Detention

Permeable Pavement is an alternative to traditional impervious asphalt or concrete surfaces like parking lots, sidewalks, or courtyards. Permeable pavement refers to multiple engineered devices that create openings in otherwise impervious surfaces to allow for filtration. Pervious pavement is best used in light traffic areas, such as parking lots. Typical examples include: pervious concrete, porous asphalt, and interlocking concrete pavers.



Permeable pavement surfaces work well in conjunction with underground storage to mitigate peak flows off large parking lots. Underground detention stores runoff in HDPE or concrete structures underneath parking lots or sidewalks. Since the cost to retrofit existing parking lots to permeable pavement can be considerable, the best opportunity to implement permeable pavement would be the redevelopment of Buckroe Shopping Center as described in the Buckroe Master Plan.



Table 3-6: Permeable Pavement Water Quality Performance Table

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	45%	75%
Phosphorus Load Reduction	25%	25%
Total Phosphorus Reduction	59%	81%
Nitrogen Load Reduction	25%	25%
Total Nitrogen Reduction	59%	81%

## Wet Pond

Wet Ponds are Stormwater Management Facilities that detain runoff and maintain a permanent pool of water. The permanent pool promotes better particulate settling, biological activity and uptake, and reduces effluent nutrient loads by diluting runoff. Wet ponds can treat a large volume of contributing drainage area making them attractive for large developments; however, this device is a less desirable choice as a stormwater management facility retrofit due to their size and propensity to attract waterfowl and mosquitoes.



**Table 3-7: Wet Pond Water Quality Performance Table**

Stormwater Function	Level 1 Design	Level 2 Design
Annual Runoff Volume Reduction (RR)	0%	0%
Phosphorus Load Reduction	45%	65%
Total Phosphorus Reduction	45%	65%
Nitrogen Load Reduction	20%	30%
Total Nitrogen Reduction	20%	30%

## Wet Swale

Wet Swales are a hybrid between grass swales and constructed wetlands. They are a linear conveyance system with wetland plants that filter and treat stormwater runoff. Wet swales have a reduced function from constructed wetlands because they lack varying topology and biodiversity; however, they are well suited within the coastal plain. Wet swales have a high tendency to attract mosquitoes and should be located away from residences, schools, and parks.

**Table 3-8: Wet Swale Water Quality Performance Table**

Stormwater Function	Level 1	Level 2
Annual Runoff Volume Reduction (RR)	0%	0%
Phosphorus Load Reduction	20%	40%
Total Phosphorus Reduction	20%	40%
Nitrogen Load Reduction	25%	35%
Total Nitrogen Reduction	25%	35%



## Urban Stream Restoration

Urban Stream Restoration is recognized as a watershed strategy effective at reducing nutrient and sediment loads to the Chesapeake Bay. The following four protocols are used in calculating potential nutrient and sediment reductions:

- **Protocol 1** – Credit for Prevented Sediment during Storm Flow
- **Protocol 2** – Credit for Instream and Riparian Nutrient Processing During Base Flow
- **Protocol 3** – Credit for Floodplain Reconnection Volume
- **Protocol 4** – Credit for Dry Channel Regenerative Stormwater Conveyance as an Upland Stormwater Retrofit

Table 3-9 below includes interim approved removal rates for urban stream restoration that can be utilized for planning purposes.

**Table 3-9: Interim Removal Rates per Linear Foot of Qualifying Stream Restoration (lb./ft. per year)**

Source	Total Nitrogen (N)	Total Phosphorous (P)	Total Suspended Solids (TSS)
Interim Chesapeake Bay Program Rate	0.20	0.068	310

**Note:** The rates listed above were taken from the “Recommendations of the Expert Panel to Define Removal Rates for Individual Stream Restoration Projects” dated May 13, 2013.

A review of the study area streams showed that there are currently no identified reaches that would qualify for urban stream restoration credits for TMDL compliance. Since the average cost per pound of phosphorous removed is around \$5,000-\$7,000, urban stream restoration is an efficient means of obtaining TMDL credit and should be pursued in other watersheds.

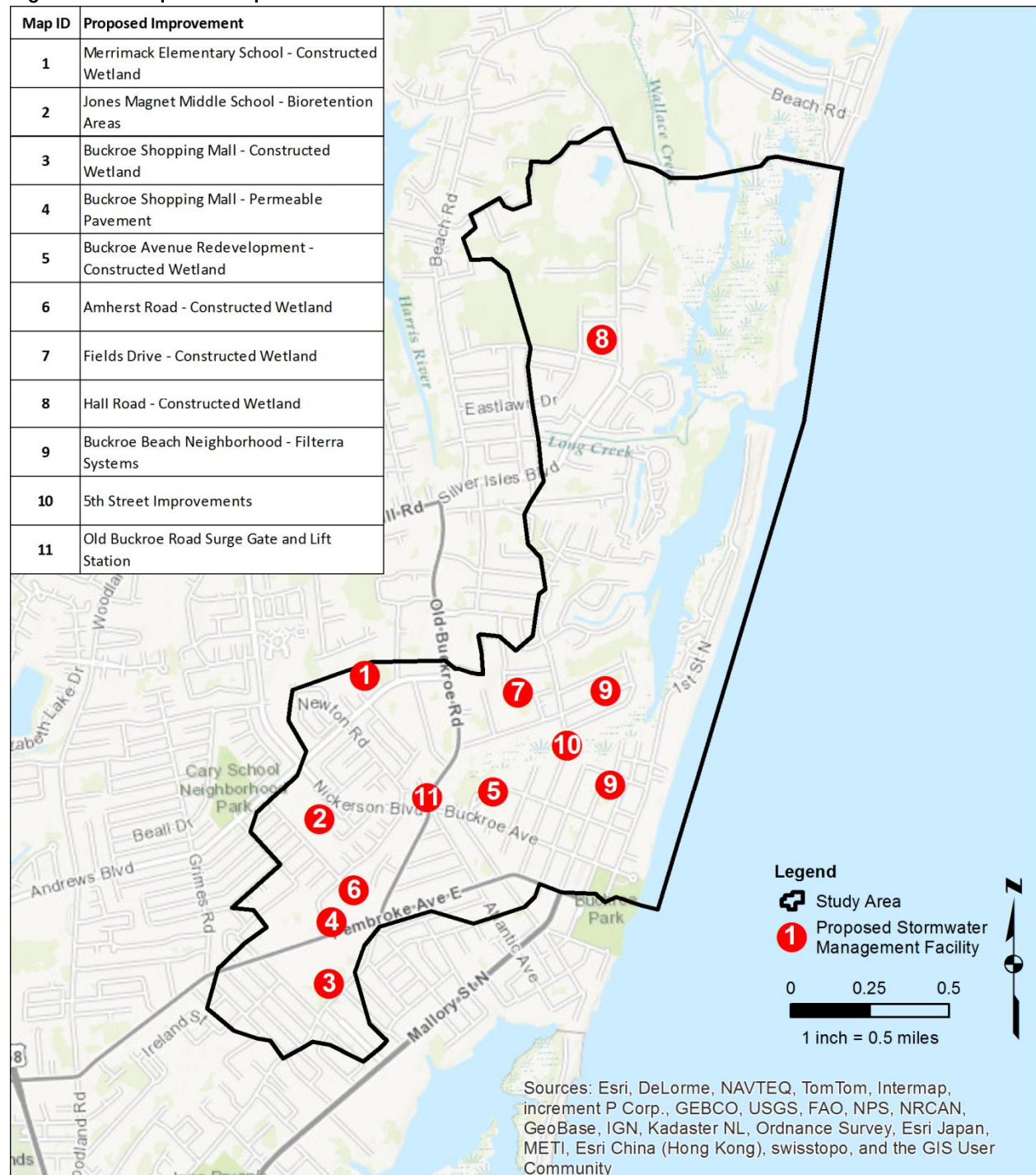
## Proprietary Bioretention System – Filterra

Filterra Stormwater Bioretention Filtration Systems (Filterras) are proprietary bioretention devices. A Filterra is a concrete box fitted with an inlet (usually a curb inlet) and an outlet to a storm sewer system. The device is usually situated behind a curb and gutter. The box is partially filled with proprietary bioretention media which mechanically and biologically removes pollutants from runoff which has entered the device through the inlet of the device. Treated runoff then passes to the storm sewer outlet within the device. Filterras incorporate trees and/or shrubs in a grated opening in the top of the device. The roots of the trees and/or shrubs grow into the proprietary bioretention media within the concrete box in order to take up additional pollutants from runoff which has entered the device. Filterras are available in various sizes to fit a variety of applications and are recognized as an effective stormwater BMP by the Virginia BMP Clearinghouse.

## CHAPTER 4: PROPOSED IMPROVEMENTS

This section discusses several options to construct new stormwater management facilities within the Buckroe and Riley's Way watersheds to help meet the City's TMDL nutrient reduction requirements and also reduce flooding.

Figure 4-1: Proposed Improvements



## Site 1: Merrimack Elementary School – Constructed Wetland

**Approach** – This improvement involves the construction of a stormwater wetland adjacent to Merrimack Elementary School. The proposed stormwater wetland is approximately 0.88 acres in size and is located on a city owned parcel. Stormwater runoff from approximately 25 acres of the adjacent residential area could be diverted to the potential stormwater wetland site. This stormwater wetland treat stormwater runoff while at the same time providing extended detention of stormwater flows from the existing drainage network within the neighborhood. The project could also include educational features such as trails and signage that the school system could incorporate into the curriculum. It is estimated that this improvement will cost approximately \$240,000. The proposed location and layout of the Merrimack Elementary School constructed wetland is included in Appendix A.

**Flooding Improvements** – Reduction of flooding events within the respective drainage area would be an added benefit of this project. The proposed wetland would be capable of attenuating runoff that would have previously drained through the adjacent storm-drain system.

**Effects on Water Quality** – This proposed stormwater wetland could potentially reduce annual phosphorus loading by up to 15 pounds and could reduce annual nitrogen loading by up to 43 pounds. It is also estimated that 3,775 pounds of total suspended solids/sediments could be reduced per year with proper maintenance of the stormwater wetland. Additionally, stormwater wetlands can provide 70% or higher removal efficiencies for influent fecal coliform.

## Site 2: Jones Magnet Middle School – Bioretention Areas

**Approach** – This improvement involves the construction three bioretention cells adjacent to Jones Magnet Middle School. The proposed bioretention areas are approximately 1.55 acres, combined, in size and are located on a city owned parcel. Stormwater runoff from approximately 16 acres of the adjacent school area could be diverted to the potential bioretention sites. These bioretention cells could then treat the runoff while at the same time enhancing the capacity of the existing drainage network within the neighborhood. Level 2 bioretention is capable of 80% runoff reduction for the first 1.0 inch of runoff. The project could also include educational features such as trails and signage that the school system could incorporate into the curriculum. It is estimated that this improvement will cost approximately \$440,000. The proposed location and layout of the Jones Magnet Middle School bioretention areas is included in Appendix A.

**Flooding Improvements** – Reduction of flooding events within the respective drainage area would be an added benefit of this project. The proposed bioretention areas would reduce up to 80% of runoff from their respective drainage areas for the first 1.0 inch of runoff through infiltration and evapotranspiration.

**Effects on Water Quality** – The proposed bioretention areas could potentially reduce annual phosphorus loading by up to 21 pounds and could reduce annual nitrogen loading by up to 164 pounds. It is also estimated that 4,499 pounds of total suspended solids/sediments could be reduced per year with proper maintenance of the stormwater wetland. Additionally, bioretention areas can provide 70% or higher removal efficiencies for influent fecal coliform.



### Site 3: Buckroe Shopping Mall - Constructed Wetland

**Approach** – This improvement involves the construction of a stormwater wetland southeast of the intersection Pembroke Avenue and Ford Road near the Buckroe Shopping Mall. According to the Buckroe Master Plan, the site is shown as a strategic growth and redevelopment area. The redevelopment of this area poses an opportunity to implement stormwater management facilities to provide a landscaping amenity and treat runoff.



The proposed stormwater wetland is approximately 2.87 acres in size. Stormwater runoff from approximately 82 acres of the adjacent residential and commercial area could be diverted to the potential stormwater wetland site. This stormwater wetland could then treat the runoff while at the same time enhancing the drainage capacity of the existing stormwater network within the neighborhood. It is estimated that this improvement will cost approximately \$540,000. The proposed location and layout of the Buckroe Shopping Mall constructed wetland is included in Appendix A.

**Flooding Improvements** – Reduction of flooding events within the respective drainage area would be an added benefit of this project. The Buckroe Shopping Mall and adjacent residential neighborhood is listed as an area of concern for flooding. The proposed wetland would be capable of attenuating runoff that would have previously drained through the adjacent storm-drain system and may help alleviate flooding in the drainage area. The extended detention of the flood flows within the wetland reduces the peak discharge necessary through the existing drainage system, therefore reducing the hydraulic grade line within the drainage network.

**Effects on Water Quality** – This proposed stormwater wetland could potentially reduce annual phosphorus loading by up to 45 pounds and could reduce annual nitrogen loading by up to 127 pounds. It is also estimated that 11,205 pounds of total suspended solids/sediments could be reduced per year with proper maintenance of the stormwater wetland. Additionally, stormwater wetlands can provide 70% or higher removal efficiencies for influent fecal coliform.

### Site 4: Buckroe Shopping Mall – Permeable Pavement

**Approach** – This improvement involves the construction of a permeable pavement parking lot for the Buckroe Shopping Mall. According to the Buckroe Master Plan, the site is discussed as a strategic growth and redevelopment area. The current condition of the parking lots are very poor and will



likely require resurfacing and additional stormwater management facilities if it is redeveloped.

The proposed permeable parking lot is approximately 6 acres in size. Stormwater runoff from the parking lot itself and portions of the buildings could be diverted to the permeable pavement parking lot. This permeable parking lot could then treat the stormwater runoff while at the same time enhancing the capacity of the existing drainage network in the adjacent neighborhood. It is estimated that this improvement will cost approximately \$290,000. The proposed location and layout of the Buckroe Shopping Mall permeable pavement parking lot is included in Appendix A.

**Flooding Improvements** – Reduction of flooding events within the respective drainage area would be an added benefit of this project. The Buckroe Shopping Mall and parking lot is listed as an area of concern for flooding. The proposed pervious parking lot would reduce up to 75% of runoff from first 1.0 inch of rainfall runoff of the respective drainage area through infiltration and evapotranspiration.

**Effects on Water Quality** – This proposed improvement could potentially reduce annual phosphorus loading by up to 14 pounds and could reduce annual nitrogen loading by up to 122 pounds. It is also estimated that 897 pounds of total suspended solids/sediments could be reduced per year with proper maintenance of the permeable pavement.

### Site 5: Buckroe Avenue Redevelopment - Constructed Wetland

**Approach** – This improvement involves the construction of a stormwater wetland northeast of the intersection of Buckroe Avenue and Ralph Street near the former Buckroe Junior High School. According to the Buckroe Master Plan, this site is shown as a strategic growth and redevelopment area. The redevelopment of this area poses an opportunity to implement stormwater management facilities to provide a landscaping amenity and treat the redevelopment runoff.

The proposed stormwater wetland is approximately 0.91 acres in size and is located on a city owned parcel. Stormwater runoff from approximately 26 acres of the adjacent residential area could be diverted to the potential stormwater wetland site. This stormwater wetland could then treat the runoff while at the same time enhancing the capacity of the existing drainage network within the neighborhood. It is estimated that this improvement will cost approximately \$230,000. The proposed location and layout of the Buckroe Avenue Redevelopment constructed wetland is included in Appendix A.

**Flooding Improvements** – Reduction of flooding events within the respective drainage area would be an added benefit of this project. The residential neighborhood south of the proposed stormwater wetland is listed as an area of concern for flooding. The proposed wetland would be capable of attenuating peak runoff flows that would have previously drained through the adjacent storm-drain system and will help alleviate flooding in the drainage area.

**Effects on Water Quality** – This proposed stormwater wetland could potentially reduce annual phosphorus loading by up to 12 pounds and could reduce annual nitrogen loading by up to 36 pounds. It is also estimated that 3141 pounds of total suspended solids/sediments could be reduced per year with proper maintenance of the stormwater wetland. Additionally, stormwater wetlands can provide 70% or higher removal efficiencies for influent fecal coliform.

## Site 6: Amherst Road - Constructed Wetland

**Approach** – This improvement involves the construction of a stormwater wetland south of the intersection of Amherst Road and Skyline Drive and northeast of the Buckroe Shopping Mall. According to the Buckroe Master Plan, the Buckroe Shopping Mall area is discussed as a strategic growth and redevelopment area. The redevelopment of this area poses an opportunity to implement stormwater management facilities to provide a landscaping amenity and treat the redevelopment runoff.



The proposed stormwater wetland is approximately 2.23 acres in size and is located across five residential and commercial parcels. Stormwater runoff from approximately 64 acres of the adjacent residential and commercial area could be diverted to the potential stormwater wetland site. This stormwater wetland could then treat the runoff while at the same time enhancing the drainage capacity of the existing stormwater network within the neighborhood. It is estimated that this improvement will cost approximately \$600,000. The proposed location and layout of the Amherst Road constructed wetland is included in Appendix A.

**Flooding Improvements** – Reduction of flooding events within the respective drainage area would be an added benefit of this project. The commercial shopping center south of the proposed stormwater wetland is listed as an area of concern for flooding. The proposed wetland would be capable of attenuating runoff that would have previously drained through the adjacent storm-drain system and should help alleviate flooding in the drainage area.

**Effects on Water Quality** – This proposed stormwater wetland could potentially reduce annual phosphorus loading by up to 38 pounds and could reduce annual nitrogen loading by up to 109 pounds. It is also estimated that 9,619 pounds of total suspended solids/sediments could be reduced per year with proper maintenance of the stormwater wetland. Additionally, stormwater wetlands can provide 70% or higher removal efficiencies for influent fecal coliform.

## Site 7: Fields Drive - Constructed Wetland

**Approach** – This improvement involves the construction of a stormwater wetland southeast of the intersection of Fields Drive and Jayne Lee Drive. The proposed stormwater wetland is approximately 0.50 acres in size and is located on an empty residential parcel. Stormwater runoff from approximately 14 acres of the adjacent residential area could be diverted to the potential stormwater wetland site. This stormwater wetland could then treat stormwater while at the same time enhancing the capacity of the existing drainage network within the neighborhood. It is estimated that this improvement will cost approximately \$140,000. The proposed location and layout of the Fields Drive constructed wetland is included in Appendix A.



**Flooding Improvements** – Reduction of flooding events within the respective drainage area would be an added benefit of this project. The proposed wetland would be capable of attenuating runoff that would have previously drained through the storm drain system.

**Effects on Water Quality** – This proposed stormwater wetland could potentially reduce annual phosphorus loading by up to 7 pounds and could reduce annual nitrogen loading by up to 19 pounds. It is also estimated that 1,656 pounds of total suspended solids/sediments could be reduced per year with proper maintenance of the stormwater wetland. Additionally, stormwater wetlands can provide 70% or higher removal efficiencies for influent fecal coliform.

### Site 8: Hall Road - Constructed Wetland

**Approach** – This improvement involves the construction of a stormwater wetland northwest of the intersection of Hall Road and Silver Isles Boulevard. The proposed stormwater wetland is approximately 0.64 acres in size. Stormwater runoff from approximately 19 acres of the adjacent residential area could be diverted to the potential stormwater wetland site. This stormwater wetland could then treat stormwater while at the same time enhancing the capacity of the existing drainage network within the neighborhood. It is estimated that this improvement will cost approximately \$270,000. The proposed location and layout of the Hall Road constructed wetland is included in Appendix A.



**Flooding Improvements** – Reduction of flooding events within the respective drainage area would be an added benefit of this project. The proposed wetland would be capable of attenuating peak runoff flows that would have previously drained through the storm drain system.

**Effects on Water Quality** – This proposed stormwater wetland could potentially reduce annual phosphorus loading by up to 8 pounds and could reduce annual nitrogen loading by up to 24 pounds. It is also estimated that 2,072 pounds of total suspended solids/sediments could be reduced per year with proper maintenance of the stormwater wetland. Additionally, stormwater wetlands can provide 70% or higher removal efficiencies for influent fecal coliform.

### Site 9: Buckroe Beach Neighborhood Filterra Systems

**Approach** – This improvement involves the installation of stormwater pipes, curb, and gutter in locations that are currently served by roadside drainage ditches. These areas provide an opportunity to implement Filterra systems at inlets to provide a landscaping amenity and treat runoff. Stormwater runoff from the adjacent residential areas would be diverted to the potential Filterra systems. The use of Filterra, or other closed box bioretention device, is recommended in these

neighborhoods because high groundwater due to the proximity to the Salt Ponds would make conventional bioretention areas ineffective.

**Flooding Improvements** –The proposed Filterra systems would not provide runoff reduction in flooding events.

**Effects on Water Quality** – This proposed Filterra systems would reduce annual phosphorus, nitrogen, and total suspended solids/sediment loading. The cost per pound of phosphorous removal is too high to be recommended as an efficient tool to meet TMDL reduction goals; however, it can provide a community amenity in restrictive urban sites.

### Site 10: 5<sup>th</sup> Street Improvement

**Approach** – The proximity of the Buckroe and Riley's Way watersheds to the Chesapeake Bay is a valuable community amenity; however, that proximity to the Bay also subjects the stormwater drainage infrastructure to high tides and surge which can reduce conveyance capacity and cause flooding. The Salt Ponds are the main stormwater artery and drain the Buckroe watershed to the Chesapeake Bay. This flood control improvement is centered around preventing surge from backing up from the Salt Ponds into the neighborhoods in order to maximize available storage and conveyance capacity.



5<sup>th</sup> street is the only road that crosses the tidal wetlands upstream of the Salt Ponds. The roadway elevation is approximately 2 ft at its lowest point where a single 72 inch diameter pipe connects the tidal wetlands. Since the roadway elevation is so low, the road often floods with relatively frequent high tides and is unsafe to navigate.

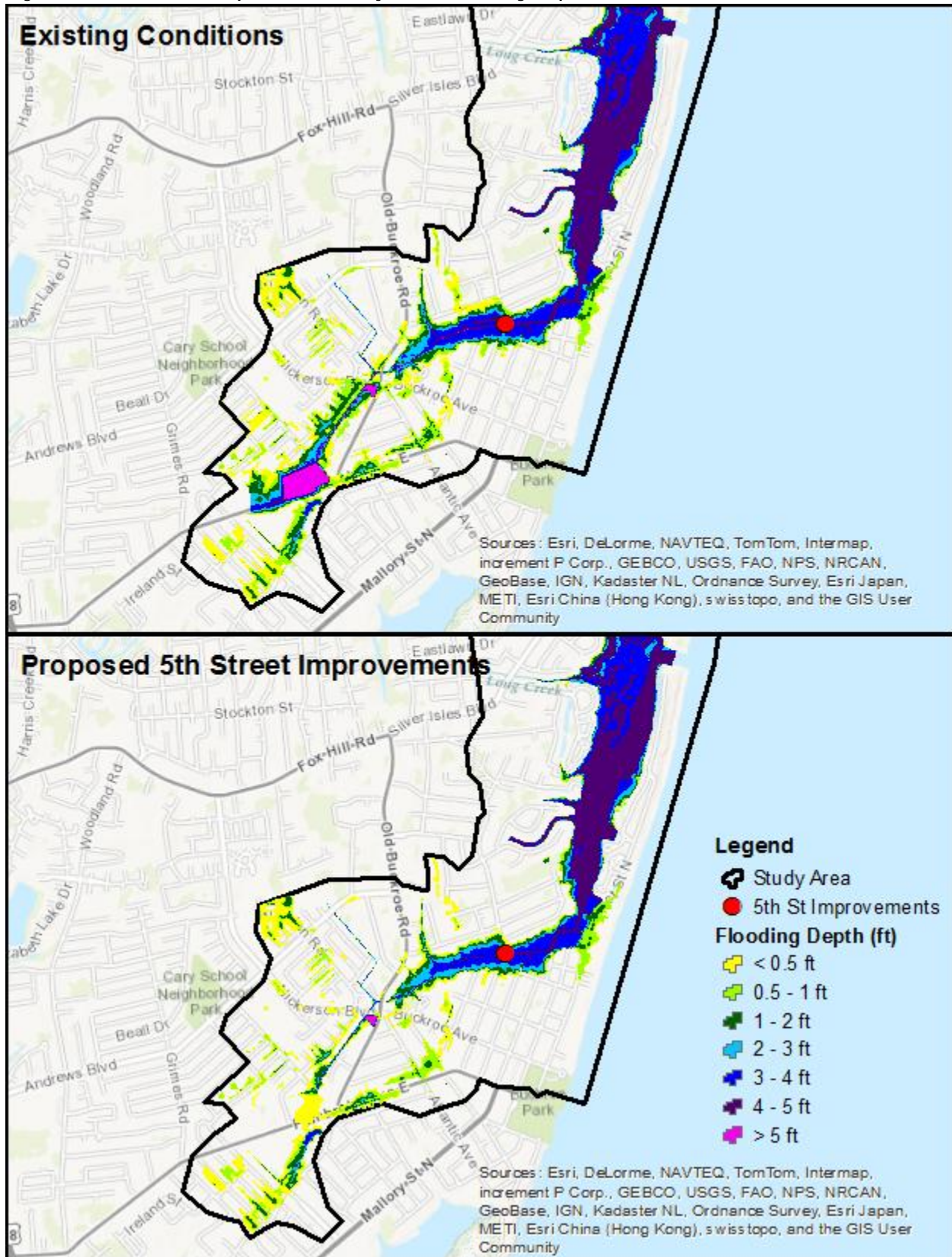
It is recommended that the elevation of 5<sup>th</sup> street should be raised to at least 5 ft and a sluice gate be installed to block storm surges up to the 5-yr surge from flowing upstream into the drainage system.

**Flooding Improvements** – This improvement would provide a safe thoroughfare across the Salt Ponds and would reduce instances of tidal surge flooding for 35 percent of the study area. This is accomplished by blocking the tidal surge while at the same time maximizing available storage in the 19 acres of existing tidal wetlands upstream of 5<sup>th</sup> Street.

Figure 3-3 below shows models results of this recommended improvement. Flooding is dramatically reduced along the Newton Rd corridor and additional improvements can be made with the addition of other stormwater management facilities within the watershed.



Figure 4-2: 5th Street Improvement 10-yr Rain Flooding Depths





**Effects on Water Quality** – This proposed improvement provides no direct improvement to water quality. Indirect improvements to water quality will be realized by reducing flooding of homes, sheds, garages, and vehicles which mobilize soluble pollutants and discharge these into the Chesapeake Bay. Since the proposed gate would only be closed during surge events, there should be no impact to existing tidal wetlands other than direct impacts of the footprint of the raised roadway.

### Site 11: Old Buckroe Road Surge Gate and Lift Station

**Approach** – This improvement includes a surge gate and stormwater lift station at Old Buckroe Road to block tidal surges and pump rainfall runoff from the upstream system. This would lower the hydraulic grade line within the drainage system during storm events with tidal surge in combination with rainfall. A pump station would be necessary in this situation because the upstream drainage network has limited storage volume for retaining rainfall runoff. A surge gate at this location would primarily only protect surge events with low rainfalls, a combination surge gate and lift station would protect against combinations of surge and higher rainfall.



**Flooding Improvements** – This option is effective at lowering flood elevations during surge events with low rainfall amounts. However, due to the limited storage volume within the upstream drainage system, this option is not effective at preventing flooding during surge events in combination with moderate and high rainfall amounts. Modeling of these improvements show that a stormwater pump station would need to be sized to convey 300-400 cfs in order to maintain stormwater system conveyance for a 10-year rainfall in a scenario where the surge gate is in the closed position.

In order to maintain stormwater system conveyance during the 10-year rainfall scenario, two or more pumps in series would be required. The cost of a system of this magnitude is estimated to be over \$6 million. Additionally, the footprint of the pump station would occupy a significant area and would require acquisition and demolition of existing homes. **Due to the cost and size of the pump station necessary, this improvement is not recommended at this time.** A surge gate without a pump station at this location is ineffective at alleviating flooding due to the limited storage volume within the upstream drainage system.

**Effects on Water Quality** – This drainage improvement project provides no direct improvements to water quality.

## CHAPTER 5: CONCLUSION AND PRIORITIZATION

### A. Prioritization

Kimley-Horn conducted a comprehensive study of the Buckroe and Riley's Way sub-watersheds to identify and evaluate potential water quality and drainage improvement projects. The sites identified looked to leverage available open space on publicly owned property, act as dual drainage and water quality facilities, and maximize effectiveness to cost of implementation. Additionally, this study took into consideration long term development and looked to identify projects that could be integrated with the Buckroe Master Plan.

Preliminary construction cost estimates were prepared for each of the improvements identified as part of this watershed management plan. A summary table containing cost estimates and potential pollutant reductions for each option is included below. More detailed cost estimate information is included in Appendix C.

**Table 5-1: Proposed Pollutant Removal Summary Table**

Stormwater Feature	Total Cost	Pounds Pollutant Removed by Proposed Facility			Cost per Pound P
		P	N	TSS	
Merrimack Elementary Wetland	\$240,000	15	43	3,775	\$15,920
Jones Magnet Middle School Bioretention	\$420,000	21	164	4,499	\$21,230
Buckroe Shopping Mall Wetland	\$770,000	45	127	1,1205	\$17,260
Buckroe Shopping Mall Permeable Pavement	\$290,000	14	122	897	\$20,720
Buckroe Avenue Redevelopment Wetland	\$230,000	12	36	3,141	\$18,340
Amherst Road Wetland	\$600,000	38	109	9,619	\$15,590
Fields Drive Wetland	\$140,000	7	19	1,656	\$20,940
Hall Road Wetland	\$270,000	8	24	2,072	\$32,890

**P: Phosphorous**

**N: Nitrogen**

**TSS: Total Suspended Solids**

The ten stormwater improvements identified as part of this study were evaluated against several factors which could affect the feasibility of their implementation by considering the following elements:

- Effectiveness of improving water quality
- Effectiveness of flood reduction
- Project construction cost
- Environmental impacts/permitting feasibility
- Property ownership i.e. City owned vs. private
- Timeline for implementation

The projects were ranked to present the improvements that were the most feasible and that could be implemented first. This does not preclude implementation of two or more options concurrently. This methodology is meant to help rank the projects in order of their ability to provide immediate water quality improvements and/or flood reduction improvements with minimal design and property/easement acquisition time.

**Table 5-2: Water Quality Improvement Prioritization**

Priority	Stormwater Feature	Cost per Pound Phosphorous Removed	Land Acquisition Needed?
1	Merrimack Elementary Wetland	\$15,920	No
2	Jones Magnet Middle School Bioretention	\$21,230	No
3	Buckroe Avenue Redevelopment Wetland	\$18,340	Yes
4	Buckroe Shopping Mall Wetland	\$17,260	Yes
5	Amherst Road Wetland	\$15,590	Yes
6	Fields Drive Wetland	\$20,940	Yes
7	Hall Road Wetland	\$32,890	Yes
8	Buckroe Shopping Mall Permeable Pavement	\$20,720	Yes

In addition to the proposed stormwater management facilities, the 5<sup>th</sup> Street Improvement is recommended to provide a safe thoroughfare across the Salt Ponds and reduce instances of tidal surge flooding for approximately 35 percent of the study area.



## B. Conclusion

This report outlines several feasible improvements that can be implemented in the Buckroe Beach and Riley's Way watershed to improve water quality and reduce flooding. It is recommended that the improvements identified and prioritized in this report be reviewed by the City of Hampton's Department of Public Works staff, City Council, and the affected citizens. As mentioned in the Prioritization section of this report, two or more of the proposed recommendations can be acted on concurrently by the City. In addition to the proposed stormwater management facilities, the 5<sup>th</sup> Street Improvement is recommended to provide a safe thoroughfare across the Salt Ponds and reduce instances of tidal surge flooding for approximately 35 percent of the study area.

Most of the drainage deficiencies identified in the stormwater system are the result of tidal water reducing the capacity of the existing stormwater infrastructure to convey rainfall runoff from the neighborhoods to the outfalls. Most improvements identified in this report, such as Level 1 stormwater wetlands, provide water quality treatment as well as stormwater retention which in turn reduces flood elevations within the drainage system. It is recommended that projects that provide water quality treatment as well as flood reduction be implemented first as outlined in the Prioritization section of this report.